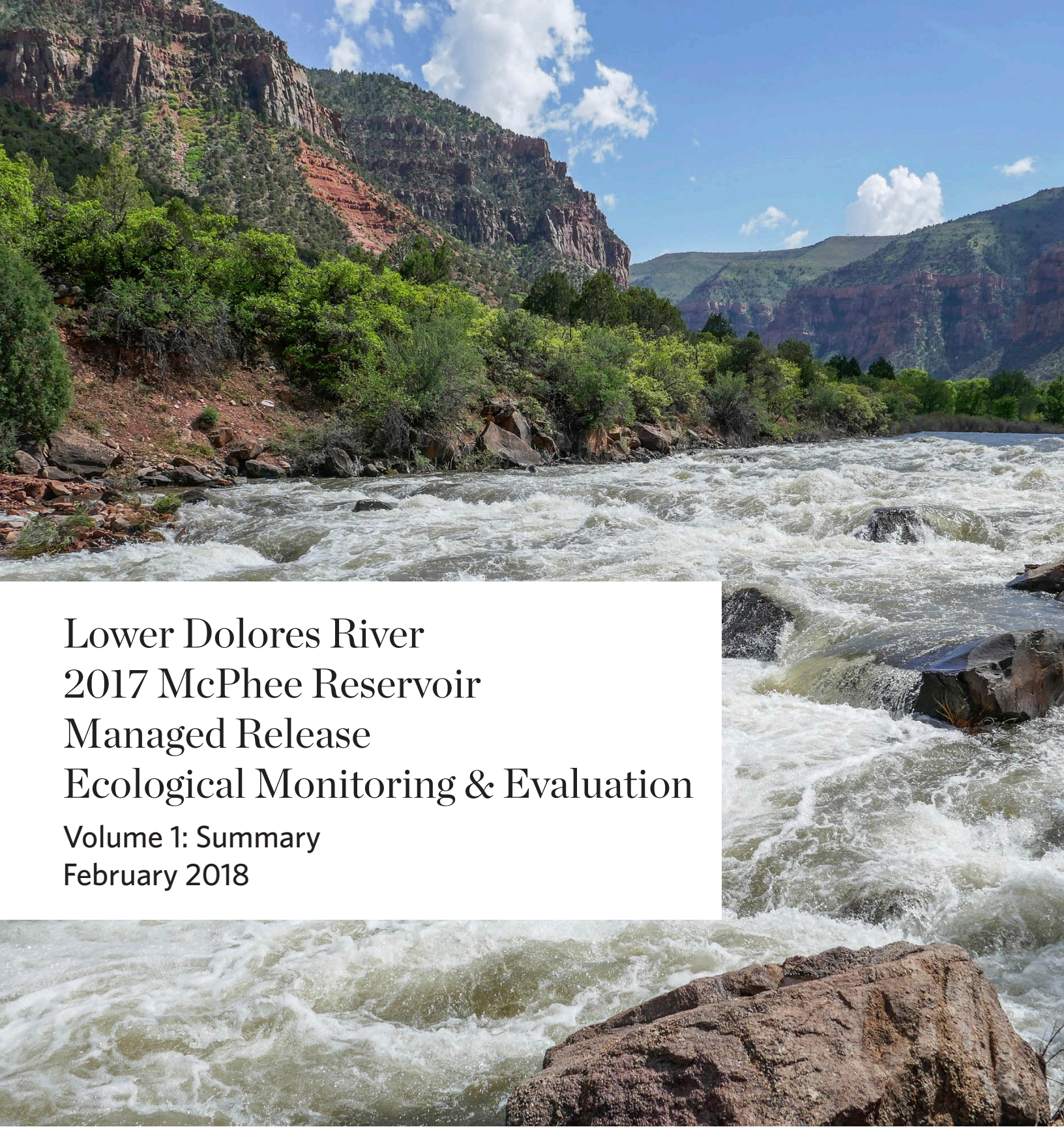


Lower Dolores River
2017 McPhee Reservoir
Managed Release
Ecological Monitoring & Evaluation

Volume 1: Summary

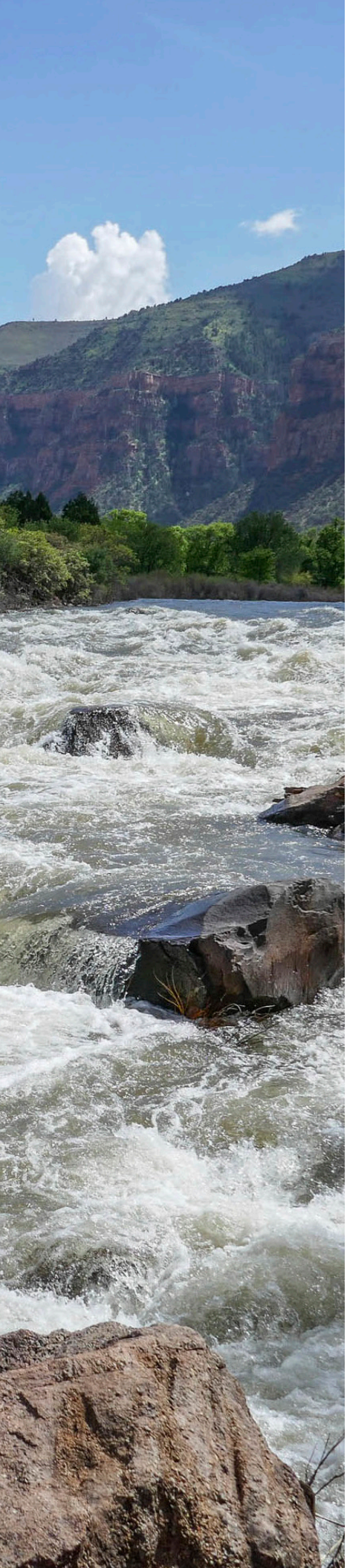
February 2018

Colorado Parks • Wildlife

The Nature Conservancy

Colorado Mesa University
Ruth Powell Hutchins Water Center

Fort Lewis College



EXECUTIVE SUMMARY

In 2014, a diverse group of stakeholders working together on the Dolores River finalized the Lower Dolores River Implementation, Monitoring and Evaluation Plan for Native Fish ('2014 Plan'). It was designed to provide specific guidance on monitoring and management actions to improve the status of native fish populations on the Lower Dolores River while respecting existing water rights, water allocations, Dolores Project contracts, and other Project commitments including the tailwater trout fishery and mitigations for whitewater boating. The Dolores River Native Fish Monitoring & Recommendation Team ('M&R Team') was also created to provide guidance and identify opportunities for future 2014 Plan implementation.

Release management, and especially the management of larger releases from McPhee Reservoir, is identified as an important opportunity for native fish in the 2014 Plan. In the winter of 2016/2017, water elevations in McPhee Reservoir, the snowpack in the Dolores River Basin, and forecasting for the 2017 water year all began to point towards the possibility of a large managed release from the reservoir into the Lower Dolores River in the spring of 2017. As such, the Dolores Water Conservancy District (DWCD), Bureau of Reclamation (BOR), and M&R Team began work using the 2014 Plan to identify opportunities for this release to benefit native fish and the associated river ecology below McPhee Reservoir.

The 2014 Plan sets forth specific habitat objectives for native fish (and associated measurable benchmarks) hypothesized to be achievable at four different flow ranges (pp. 29-30), as well as spelling out four native fish assumptions for all managed release scenarios (p. 27). Habitat goals range from flushing of fine sediments and thermal regime management at lower forecasted releases, to habitat maintenance and inducing channel heterogeneity at higher forecasted release volumes. In planning for a potential managed release, reservoir managers determine which flow level(s) might be possible, then researchers plan monitoring efforts to evaluate the success of the managed release in accomplishing habitat objectives associated with those target flow level(s).

Reservoir managers determined it might be possible to achieve all four target flow ranges with the 2017 managed release and aimed to address all four native fish assumptions. The M&R Team developed a plan to evaluate as many measurable benchmarks as possible associated with the habitat objectives for each target flow range. In March 2017, The Nature Conservancy (TNC) and Colorado Parks & Wildlife (CPW) (both members of the M&R Team) launched this monitoring effort with support from Fort Lewis College, Colorado Mesa University, Bureau of Land Management, United States Forest Service, private landowners, and volunteers. Monitoring focused on: (1) sensitive native fish; and (2) assessment of in-channel and riparian habitat. Select pre- and post-release data were collected on five newly established ecological monitoring sites and at multiple other sites.

Dolores River © *John Fielder*

The first strategic reservoir release on the Dolores River to be conducted in association with the 2014 Plan and to address specific ecological targets was managed by the DWCD and BOR, with assistance from the M&R Team, in 2017. It ran for 86 days with an overall total of 208,190 AF released, and downstream releases collectively totaling 63 days at or above 800 cfs, 40 days at or above 1,200 cfs, 11 days at or above 2,000 cfs, and 3 days at 4,000 cfs. Table 1 below shows how the 2017 managed release achieved target flow ranges and native fish assumptions.

Table 1. Summary showing how the 2017 managed release achieved the four target flow ranges and four native fish assumptions.

Target Flow/Native Fish Assumption	How Addressed with 2017 Managed Release
Target - Flushing Flow: 400-800 cfs to scour fine sediment Assumption - Provide flushing flows to prepare spawning bed (~400-800 cfs)	Flushing flows in 400-800 cfs range were achieved during the 2017 release
Target - Flushing Flow: 800-2,000 cfs to initiate mobilization of the median-size particle	Flushing flows in the 800-2,000 cfs range were achieved during the 2017 release.
Target - Habitat Maintenance Flow: 2,000-3,400 cfs for 7+ days (bankfull flows)	Habitat maintenance flows over 2,000 cfs were achieved for more than 7 days.
Target - Habitat Maintenance Flow: Peak flows of >3,400 cfs at frequency of ~7-10 yrs	Peak flows of >3,400 cfs were achieved in early May.
Assumption - Preventing thermal shock: improve ascending spring flows beginning April 1 that ramp sufficiently to minimize pre-release water warm-up that triggers pre-release spawn	Water managers were prepared to make spring releases to prevent thermal shock in 2017, but the early runoff and pre-April 1 start to the release made those thermal regime management releases unnecessary.
Assumption - Attempt to mimic natural pattern of flows during a spill at times most critical to native fish	The 2017 Release was planned and adjusted to mimic a natural pattern of flows under the weather and runoff conditions of 2017.
Assumption - Recession limb of 200 cfs decrease over two days can be used to provide monitoring conditions and assist boaters. This can provide a sufficient three-day period of 400-500 cfs for monitoring.	The ramping criteria were used during the 2017 release to assist boaters and for ecological purposes (including the avoidance of stranding native fish during the recession limb). Water managers worked with CPW to provide appropriate flows for a multiple-day electrofishing survey of Slickrock Canyon (last surveyed in 2007).

Additionally, water managers and the Dolores River Biology Committee worked together to ensure the 2017 managed release was of long enough duration that the Biology Committee could recommend using fish pool water to support a non-native fish removal effort in the Pyramid Reach (also an opportunity identified in the 2014 Plan) after the release ended (in July of 2017).

One challenge of the 2017 monitoring effort was unusually early low-elevation runoff that reduced opportunities to monitor some aspects of instream habitats (riffle dynamics and longitudinal dimensions within the channel). Runoff from the Dolores Rim and the Dolores/Norwood plateau regions elevated flows in the Dolores below McPhee beginning in early March, and peaked at or above 600 cfs during the pre-release sampling period, making it impossible to perform all of the instream assessments envisioned in the plan.

Overview of Major Findings

The status of native fish in the Lower Dolores River has improved over where it was a decade ago, with increases in native fish capture and documented evidence of reproduction. The 2017 managed release benefitted in-channel habitat for native fish. For habitat along the channel, results were mixed. The high flows during the 2017 managed release caused very limited river bank erosion and thinning/removal of riparian vegetation because unnaturally dense vegetation growing along much of the Lower Dolores River has 'armored' the river banks. Despite these armored banks, substantial interaction between the channel and the floodplain occurred, with overbank flooding documented at multiple sites, resulting in noticeable sediment deposition and scour and recharging of the alluvial aquifer.

Key observations of ecological response to the release include:

Sensitive Native Fish

- There was a 95% increase in catch per unit effort (CPUE) over 2007 for all three sensitive native fish species (flannelmouth sucker, bluehead sucker, and roundtail chub). In 2017, 0.43 fish per minute were caught, compared to 0.22 fish per minute in 2007. Despite this improvement, overall density of native fishes is still low.
- All species of sensitive native fish reproduced in 2017. Roundtail chub reproduction was evident at most sites; bluehead sucker and flannelmouth sucker reproduction was also detected, but at low levels. Detection of small new fish is difficult, so surveys in future years will provide a better indication of how much native fish reproduction occurred in 2017.
- Slickrock Canyon is still a stronghold for native species, with the three sensitive native species comprising 88% of the total catch (flannelmouth suckers comprising 53% of the catch, roundtail chub 32%, and bluehead sucker 3%).
- Non-native fish known to prey on native fish have increased. Specifically, smallmouth bass have increased in the Pyramid reach. Other non-native species with small populations that should be monitored are channel catfish, green sunfish, red shiner, and redside shiner.
- One white sucker was found in Slickrock Canyon. This species had not previously been documented below McPhee Dam. White suckers hybridize with native suckers, and are a serious threat to the genetic integrity of native suckers.

In-channel and Riparian Habitat

Through most alluvial ecological monitoring sites, there was evidence of scouring and evacuation of material within surveyed pools, with some evidence of floodplain deposition at a few of these sites, confirming that the release transported sediment and increased pool volume. For example, at the BLM Rec (Big Gypsum) site, mean pool depth increased by more than 3 feet, changing the cross-sectional area from 433 square feet pre-release to 1,226 square feet post-release, increasing pool volume by almost 300%.

- At a low-floodplain location at the Slickrock Downstream site, fine sediments (2 mm particles) were almost completely removed by the release and larger cobbles were moved. Median particle size at this location increased 27%, from 85 mm to 108 mm. This low-floodplain finding suggests

that in-channel riffles were at least equally coarsened by the managed release, improving native fish breeding and foraging habitat.

- Except for bank erosion at one site, there was little evidence that the managed release eroded banks and increased channel width, as would be expected during a natural flood. This suggests that the Dolores River is stabilizing within a narrower channel.
- Historic photo comparison confirms that the density of riparian vegetation and consequent 'armoring' of river banks has increased substantially from 2003 to 2017 on multiple sites along the Dolores.
- The configuration of the channel as seen from above (the planform) was little changed.
- Despite armored banks, overbank flooding occurred at multiple sites. This flooding allowed:
  - » Sediment deposition in many areas, up to three feet in some locations.
  - » Flood and water movement through side channels that normally remain dry.
  - » Replenishment of alluvial / floodplain aquifers. At the BLM Rec (Big Gypsum) site groundwater rose to within 2 feet of the ground, providing water to adult cottonwoods.
- The managed release created very few new bare areas where cottonwood seedlings could establish. No new cottonwood seedlings were found on the ecological monitoring sites, likely due to a combination of dense existing vegetation and timing of peak flows that did not correspond with timing of cottonwood seed release.

Summary Table

Table 4 of the 2014 Plan outlines specific native fish habitat objectives to be accomplished through release manipulation, and includes measurable indicators to be monitored in the field to determine progress towards reaching these habitat objectives. The table below (Table 2) organizes the major findings from the 2017 ecological monitoring according to the specific measurable benchmarks/indicators from Table 4 of the 2014 Plan that each of the monitoring efforts targeted and reports the progress achieved towards reaching each of the associated habitat objectives during the 2017 managed release.

Table 2. This modified version of the original Table 4 from the 2014 Plan provides the flow hypotheses, native fish habitat objectives, and measurable benchmarks/indicators from the original table in the first three columns (brown), with the fourth column (blue) reporting the major findings from the 2017 ecological monitoring for the specific measurable benchmarks/indicators they are associated with.

Flow Hypothesis	Habitat Objective	Measurable Benchmark	Overview of 2017 Monitoring Findings
Flushing Flow 400-800 cfs to scour fine Sediment	Maintain quality spawning habitat at times appropriate for spawning to occur	Quantify percentage of fines (<2mm) in spawning beds (cobbles) pre- and post-flow event; percentage of fines measured should be reduced, with specific attention paid to aligning flushing flows relative to the timing of native fish spawning.	Because of early high-flows, we were unable to monitor in-channel cobble habitats. We instead monitored low floodplain locations as surrogates for cobble habitats, and percentage of fines was reduced at these sites. For example, at the Slickrock Downstream site, 2 mm particles were almost completely removed from the site due to the 2017 managed release.
Flushing Flow 800-2,000 cfs to initiate mobilization of the median-size particle	Maintenance of riffle and pool vertical relief	D50 should coarsen in riffles; annual accumulation of fine sediment should be scoured from pools. Pool riffle profile should be maintained.	Several pools deepened (up to 5 feet in spots), and were scoured of fine sediments. Because of early high-flows, we were unable to monitor in-channel cobble habitats. We instead monitored low floodplain locations as surrogates for cobble habitats, and D50 did coarsen. For example, at the Slickrock Downstream site, D50 increased 27%, from 85 mm to 108 mm.
	Maintain benthic macroinvertebrate productivity	Taxa measurements for benthic macro-invertebrate species in riffles (quantitative/ qualitative measures?) should reflect productive instream environment.	Did not monitor in 2017.
Habitat Maintenance Flow 2,000-3,400 cfs for 7+ days (bankfull flows)	Maintain pattern and profile appropriate for the reach	Monitor changes in cross-section and profile dimensions; channel aggradation, degradation or entrenchment should be assessed; over a reach, over time, gradient and pool-riffle spacing should be consistent. Assess plan-view changes, such as stabilization of mid-channel bars or bar extension; vegetative encroachment on point bars; medial bar expansion.	Essentially no change in river plan-view. Photos taken in 2017 that repeat photos from 2003 then 2017 show stabilization of riverbank. Pools sampled in alluvial reaches confirmed scour of up to 5 ft of material, deepening pools and expanding habitat in the pools. Early high flows in 2017 precluded measurements along the length of the channel, so we were unable to assess gradient and other profile dimensions.

Flow Hypothesis	Habitat Objective	Measurable Benchmark	Overview of 2017 Monitoring Findings
Habitat Maintenance Flow 2,000-3,400 cfs for 7+ days (bankfull flows)	Scour pools	Maintenance of pool depth (see above re: pool depths).	Pool depths were increased in alluvial and confined alluvial reaches pre- vs post-release. Scour ranged from 0 to over 5 feet.
	Mobilize majority of riffle materials	Monitor mobile fraction of channel bed in riffle; tracers or direct bedload transport measurements; hydraulic modeling.	Unable to monitor riffle habitat in 2017, and did not measure bedload transport or conduct hydraulic modeling.
	Initiation of significant interaction with floodplains in alluvial reaches.	Cottonwood recruitment (or at least some indication of seed-bed preparation & germination); maintain other riparian indicators (e.g., minimize encroachment of xeric/mesic species onto floodplains). Validate Qbkf hypotheses by reach.	At all cross-sections observed overbank flows and in most cases deposition of fines on floodplains—and scour was observed at most sites—providing some seed-bed preparation. No new cottonwood recruitment observed on ecological monitoring sites. Willow encroachment/ high density likely inhibiting germination.
Habitat Maintenance Flow Peak flows of >3,400 cfs at a frequency of ~7-10 years	Mobilize & re-set riffle habitats; create & maintain instream habitat diversity (pool scour; backwaters; 2° channels)	Document movement of D84 in riffles; assess instream habitat complexity. Assess cross section and longitudinal changes.	Because of early high-flows, we were unable to monitor riffles, thus did not measure movement of D84. Observed pool scour of 0-5 ft. Some normally-dry backwaters and secondary channels flowed during peak release.
	Maintain floodplain exchange and robust riparian vegetative community	Monitor riparian vegetation diversity and density; cottonwood germination and recruitment (NOTE - Riparian monitoring will be an important indicator of whether large flows providing exchange benefits to instream resources).	Vegetative transect comparison 2010 vs 2017 show no increase in willow density. However, comparison of historic photo points show willow density appears to have increased at one site (Big Gypsum) from 2003 to 2017. Overall vegetative diversity appears reduced as willows increasingly dominate.
	Energy and nutrient exchange between channel and floodplains	Validate Qbkf hypotheses by reach. Floodplain inundation depths; measure exchange of material between channel and floodplain (e.g., painted patches; floodplain transect monitoring).	Wildlife cameras captured river stage/flood plain inundation depth. Floodplains showed both scour (Bedrock, Slickrock Downstream) and deposition (BLM Rec [Big Gypsum], Bedrock, Slickrock Downstream). At Slickrock Downstream, 3-D elevation survey showed deposition of sand occurring on floodplain (up to 3 feet), and notable incision (up to 2 feet) occurring in pre-existing side channel.
	Maintenance of alluvial aquifer	Groundwater monitoring in floodplain.	High flows and a long-duration release in 2017 improved groundwater levels at multiple sites; at Big Gypsum site groundwater rose to within 2 feet of the surface, providing needed water to pre-existing adult cottonwoods.

Key Recommendations for Future Monitoring

A section in Volume 2 presents a full and detailed list of recommendations across the full suite of monitoring that has been conducted on the Dolores. Here, we present the core elements of these recommendations based on what was learned in 2017:

- Having historic data from several sites was extremely useful for understanding long-term change. Directing future monitoring at the five new ecological monitoring sites would allow us to build on this understanding.
- The best way to know what is happening with fish populations is to sample fish, so it is essential to continue annual fish surveys at multiple sites below the Dove Creek Pumps.
- Repeat on-the-ground photo point monitoring was very useful for understanding long-term dynamics with riparian vegetation and channel planform.
- Aerial drone imagery collected to capture pre- and post-release planform changes was not particularly revealing this year, but could be useful if repeated every 5-10 years.
- Additional drone-derived photogrammetry (3-D floodplain surveys) may be useful as an important complement to painted patch and erosion stake monitoring; it does not capture data as precisely but the photogrammetry covers much more area.
- Repeating cross-section profiles at established points was useful for understanding specific in-channel sediment dynamics. These should be repeated in the future.
- In future years with release projections and similar pre-/post-release monitoring, it will be important to initiate pre-release monitoring prior to 'low snow' runoff from the Dolores Rim and Glade to complete longitudinal sampling through the ecological monitoring sites, and to ascertain riffle dynamics related to flow magnitude.
- Cottonwood recruitment and survival on the Dolores River is still poorly understood. Groundwater monitoring should be continued, as should efforts to document cottonwood establishment (or lack thereof).
- Continue to repeat historic vegetation transects with future managed release events, and/or at select long-term intervals (e.g. every 5-10 years)
- Since management of water temperature is specifically called out in the 2014 Plan, monitoring of temperature should be continued.

Additional Information and Resources

The Dolores River ecological monitoring in 2017 is presented in two volumes and a set of appendices.

Volume 1 contains an Executive Summary that presents a summary of the release, key findings, and key recommendations. Volume 1 also presents a summary of individual monitoring methods and more detailed findings derived from each method.

Volume 2 contains details methods and findings. It also presents a more comprehensive set of recommendations for future monitoring.

In addition, a set of appendices provide further detail associated with 2017 monitoring efforts conducted on the five new ecological monitoring sites. Many of these appendices are large documents, or a collection of files. As such, all appendices were created as separate documents or folders, and can be obtained through TNC. Any additional data associated with the five new ecological monitoring sites but not contained within these appendices is housed with TNC (aerial imagery, TNC wildlife camera & staff gage data), Fort Lewis College (all other vegetation data), and Colorado Parks and Wildlife (geomorphology & sediment data). Current contacts for this information are Celene Hawkins (TNC), Dr. Cynthia Dott (Fort Lewis College), and David Graf or Ryan Unterreiner (Colorado Parks and Wildlife).

The appendices are:

- Appendix 1. Ecological Monitoring Sites – Site Locations and Descriptions
- Appendix 2. Ecological Monitoring Sites – Photo Point Monitoring Locations & Comparisons
- Appendix 3. Ecological Monitoring Sites – Staff Gage and Wildlife Camera Installation
- Appendix 4. Historic Big Gypsum Photo Point Monitoring Locations & Results
- Appendix 5. New Cottonwood Recruitment Survey Locations & Results
- Appendix 6. Photo Point Summaries of Ecological Monitoring Sites
- Appendix 7. People and Wildlife Summary
- Appendix 8. Sounds of the Dolores River
- Appendix 9. All Ecological Monitoring Site Photos Pre-, Peak-, and Post-Release
- Appendix 10. Ecological Monitoring Preliminary Findings Presentations M&R Team Meeting Oct 2017

Additional Contact Information

Any additional data associated with the five new ecological monitoring sites but not contained within these appendices is housed with TNC (aerial imagery, TNC wildlife camera & staff gage data), Fort Lewis College (all other vegetation data), and Colorado Parks and Wildlife (geomorphology & sediment data). Current contacts for this information are Celene Hawkins (TNC), Dr. Cynthia Dott (Fort Lewis College), and David Graf or Ryan Unterreiner (Colorado Parks and Wildlife).

For more detailed data collection and background information for fisheries, groundwater, and DEM/elevation data collection efforts please contact the following organizations directly: Colorado Parks and Wildlife (Jim White) for fisheries data, and Fort Lewis College for DEM/elevation data (Dr. Jonathan Harvey), and groundwater sensor and other wildlife camera river stage data (Dr. Gary Gianniny).
For more information regarding full details of the managed release itself, see the 2017 McPhee Controlled Release Summary report by Eric Sprague of the DWCD, or contact Eric Sprague or Ken Curtis directly at the DWCD. For more information on recreation boating 2017 monitoring efforts contact American Whitewater (Nathan Fey), Dolores River Boating Advocates (Amber Clark), or Bureau of Land Management (Jeff Christenson).

SUMMARY OF MONITORING METHODS & FINDINGS

The 2017 ecological monitoring efforts focused on two general areas: assessment of sensitive native fish and assessment of in-channel and riparian habitat. This section summarizes methods and findings for individual aspects of the monitoring effort. Volume 2 contains more detailed descriptions of sites, methods, and findings. A set of appendices contains further detail on methods and data collected.

Sensitive Native Fish

Fisheries Monitoring

Fisheries monitoring in 2017 was targeted primarily at improving the understanding of the distribution and abundance of native and non-native fishes in the Lower Dolores River and assessing native and non-native fish reproduction. While monitoring was being conducted, non-native invasive fish known to inhibit native fish populations were removed, and native fishes were marked with passive integrated transponder (PIT) tags to assess movement patterns and population dynamics. Monitoring efforts resulted in 50 miles of the Dolores River being surveyed (including electrofishing the entire 36-mile Slickrock Canyon, all 14 miles of the Pyramid Reach, and 1000 feet at Dove Creek Pumps; and seining low velocity habitats in 3 miles at James Ranch and 2 miles at Big Gypsum). A total of 609 native fish were marked with PIT tags throughout the summer.

Summary of Findings:

- Slickrock Canyon is still a stronghold for native species, with three native species (flannelmouth sucker, bluehead sucker, and roundtail chub) comprising 88% of the total catch out of 591 fish caught. Specifically, flannelmouth suckers comprised 53% of the catch, roundtail chub 32%, and bluehead sucker 3%.
- Overall density of native fishes is still low in Slickrock Canyon, yet a fair number of suckers are still being caught, particularly flannelmouths.
- In Slickrock Canyon, there was a 95% increase in catch per unit effort (CPUE) over 2007 for the three native fish species. In 2017, 0.43 fish per minute were caught, whereas in 2007 only 0.22 fish per minute were caught.
- Roundtail chub reproduction was evident at most sites, including the Dove Creek Pumps reach, James Ranch Reach, and Big Gypsum Reach. Young-of-the-year bluehead and flannelmouth suckers were also detected, but at low levels. Findings about 2017 reproduction are preliminary because detection of young-of-year fish is difficult; population surveys in future years will provide a better indication of how much reproduction of native species occurred this year.
- Few non-natives were found in Slickrock Canyon.
- One white sucker was found in Slickrock Canyon. This species had not previously been documented on the Dolores River below McPhee

Dolores River © *Lauryn Wachs/TNC*

Dam. White suckers hybridize with native suckers and are a serious threat to the genetic integrity of native suckers.

- Smallmouth bass (non-native predator fish that eat native fish) were found to be persistent in the Pyramid Reach, and more frequent removals of these species is recommended. CPUE was 34.6 smallmouth bass/hour in 2017, versus 13.4 in 2007, and 18 in 2011.
- No smallmouth bass were found downstream of Disappointment Creek, including in Slickrock Canyon.
- Removal of non-native fish was only possible because of the combination of the large managed release and the use of approximately 2,800 acre feet of fish pool water.
- More catfish, red shiner, and sand shiner were found in 2017 (versus surveys in 2012, 2013, and 2014), which was troubling. Shiner habitat overlaps with the habitat of young native fish, and shiners eat the natives.
- As in past years, higher trout biomass was sampled with higher discharge.

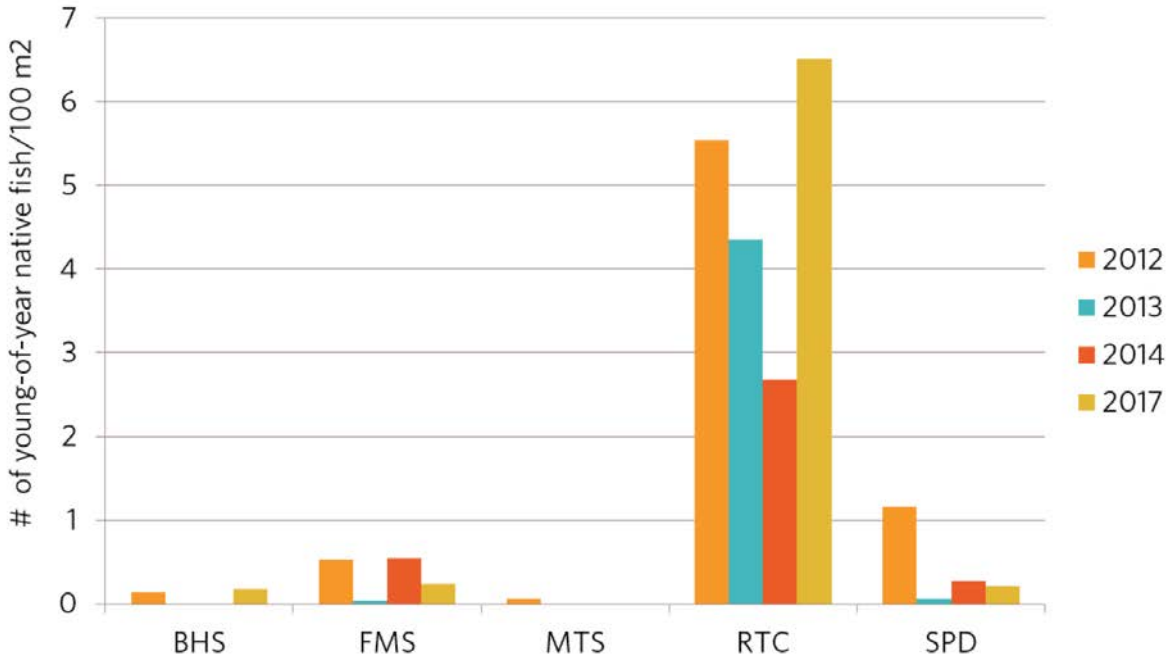


Figure 1. Young-of-year native fish by species caught in reproduction surveys on the Dolores River in 2012 (orange), 2013 (blue), 2014 (red), and 2017 (yellow). CPUE = Catch per unit effort, BHS = bluehead sucker, FMS = flannelmouth sucker, MTS = mottled sculpin, RTC = roundtail chub, and SPD = speckled dace. Reproduction of all three species of sensitive native fish occurred in 2017. Young-of-year flannelmouth suckers and roundtail chubs have been detected in every survey year. Bluehead sucker reproduced in 2017 and 2012, but were not detected in 2013 and 2014.

In-channel and Riparian Habitat

Ecological Monitoring Site Photo Point Monitoring

New repeat photo monitoring points were established at each of the five new ecological monitoring sites prior to the 2017 managed release, with photos taken pre-release (March 20-24), peak-release (May 5-7) (if points could be reached during high flows), and post-release (July 6-8) 2017. These new photo points were established to: (1) provide a visual characterization of vegetation changes, sediment scour/deposition, ground-view river bank erosion, and planform changes that might be observed pre- versus post-release in 2017; (2) establish a visual 'baseline' of the above for comparison in future years; and (3) capture the extent of overbank flooding occurring at each site during the 2017 managed release, thus helping to visually characterize floodplain inundation depth, and the interaction and exchange of material between channel and floodplain.

Summary of Findings:

- Comparison of pre- and post-release photos showed noticeable changes in sediment scour and deposition and captured substantial overbank flooding occurring at peak-release.
- Pre- and post-release photo comparison found limited changes in vegetation, river bank erosion, and planform change. These findings and photos are presented as part of other monitoring efforts in Volume 2 and in several appendices.

Geomorphology and Sediment Monitoring

Pre- and post-release monitoring was conducted by CPW on the five new ecological monitoring sites to determine effects of the 2017 managed release on site geomorphology and sediment movement. Survey efforts included cross-section surveys and Wolman pebble counts, as well as installing erosion stakes, painted patches, and sediment traps. Fort Lewis College researchers also created a topographic map comparing the landscape before and after the 2017 managed release to assess changes in sediment mobilization.

Summary of Findings

- Overall, there was noticeable evidence of scouring and evacuation of sediment within the channel and substantial deposition of this sediment on floodplains in places (up to 3 feet of deposition at the Slickrock Downstream site).
- At most alluvial ecological monitoring sites, there was evidence of scouring and evacuation of material within surveyed pools, with evidence of floodplain deposition at some sites, confirming that the release re-set vertical relief and increased overall pool volume. For example, at the BLM Rec (Big Gypsum) site mean pool depth increased by more than 3 feet, changing the cross-sectional area from 433 square feet pre-release to 1,226 square feet post-release, increasing pool volume by almost 300%.
- Little bank erosion was observed. The exception to this was the substantial bank erosion documented at one monitoring site (just upstream from the Bedrock site, where an estimated 260 tons of material eroded). Otherwise, there was little evidence that the large managed release and big peak flows eroded banks and increased channel width. This suggests that the Lower Dolores River is stabilizing within a narrower, more confined channel.
- At the Slickrock Downstream site, fine sediments (2 mm particles) were almost completely removed from the survey area with the 2017 managed release (Figure 2 below). Though the measurable benchmark associated with fine sediment removal is in reference to in-channel riffle habitats, this result is important because it indicates that higher-energy sites within the active channel were at least equally coarsened by the managed release, which improves breeding and foraging habitat for native fish.

- D50 coarsened from 85mm to 108mm on a high energy, low-floodplain environment at the Slickrock Downstream site, considered the best surrogate for in-channel processes that occurred in riffle habitats.
- At the Slickrock Downstream Site, erosion stakes on a low floodplain, high energy site showed substantial scour (Figure 3). Some cobble movement was observed into and out of the painted patch, indicating that larger particles were also mobilized with the managed release.
- At the Slickrock Downstream site, the 3-D elevation survey conducted by FLC researchers showed minimal lateral bank erosion, but found substantial deposition of sand occurring on the floodplain (up to 3 feet), particularly where river flow was slowed by dense willow, and notable incision (up to 2 feet) occurring in the pre-existing side channel.
- Reactivation of side channels was observed at several sites.

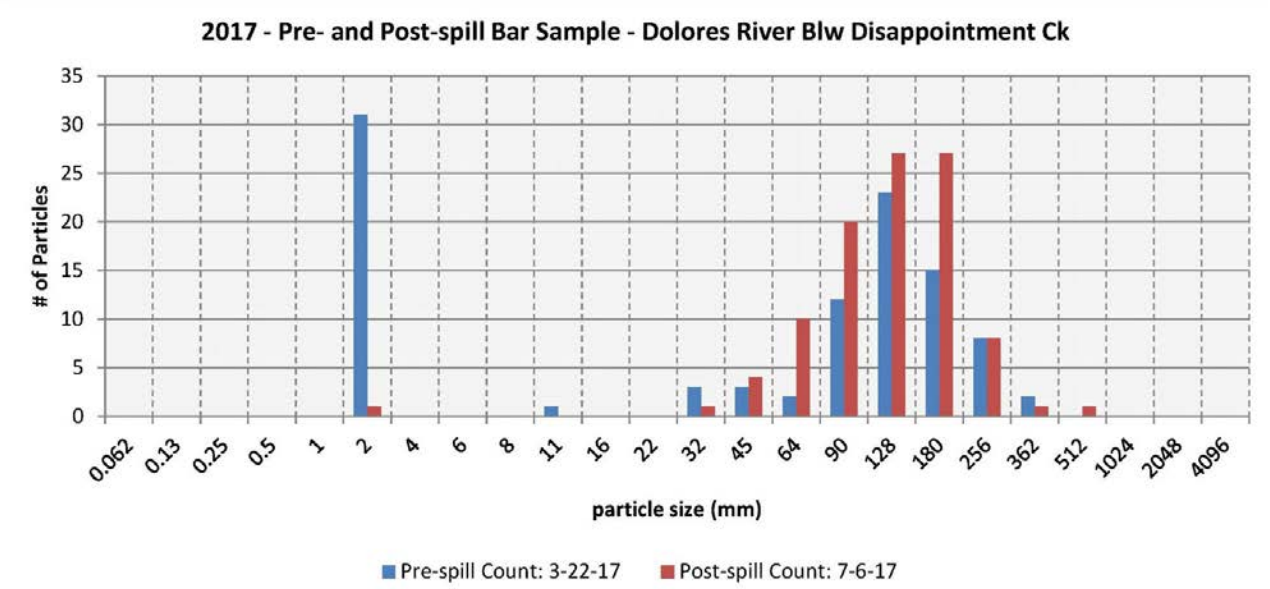


Figure 2. Slickrock Downstream (Below Disappointment Creek) site Wolman pebble count results 2017. These important results show that 2 mm particles were almost completely removed from the site.

Figure 3. Slickrock Downstream sediment trap (yellow circle) and erosion stake (blue circle); pre-release photo on left (3/22/17), and post-release photo on right (7/6/17). Note the scouring of fine material observed with the orange erosion stake between pre- and post-release. It is estimated that the sediment trap was washed away with strong scouring flows during the managed release (absence of sediment trap post-release).

Wildlife Cameras and Staff Gage Monitoring

Wildlife cameras and staff gages were installed between March 20-24, 2017 at each of the five new ecological monitoring sites. Cameras captured images of staff gages at regular intervals showing changes in flow stage height prior to, during, and after the 2017 managed release.

Summary of Findings

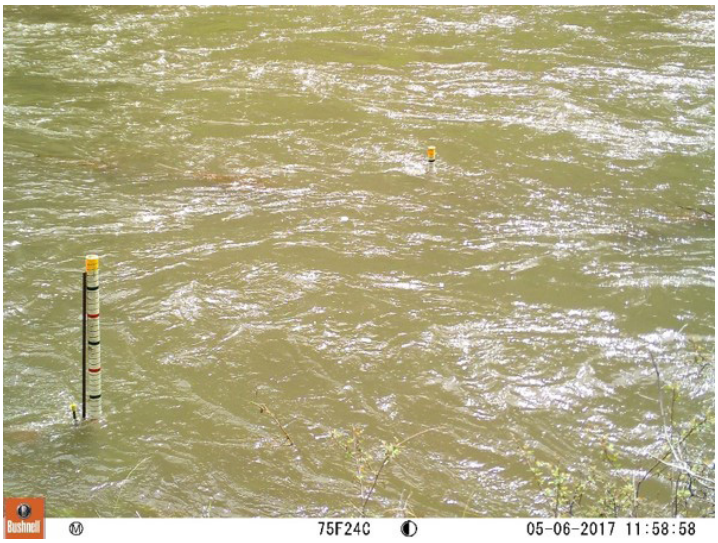
- Cameras captured the river rising substantially out of its banks at multiple sites during peak-release, an important benefit of the managed release, resulting in noticeable sediment deposition and scour, and crucial recharging of the alluvial aquifer (see Figure 4 below).
- Images do, however, also show minimal bank erosion, providing further evidence of the substantial 'armoring' of the banks at multiple sites.

Dove Creek

Before

Rising Water

Peak



After

Figure 4. Dove Creek staff gage at pre-release, rising water, peak-release, and post-release. Notice river rising substantially out of its banks at peak-release but with very little change in the amount of woody vegetation.

Groundwater Monitoring

Fort Lewis College researchers measured changes in groundwater depth in response to the 2017 high flow managed release, the 2012 moderate release, and 2011 low flow only or baseflow conditions at two sites along the Lower Dolores River (Lone Dome, Big Gypsum). Three piezometers to measure groundwater depth were installed at each site with increasing distance from rivers edge, with the middle groundwater well (Well #2) installed in the 'cottonwood zone'.

Summary of Findings

- The 2017 peak release (~4,070 cfs) resulted in peak discharge at Slickrock (the closest gage to the Big Gypsum site) of 3,630 cfs, and this resulted in floodplain inundation and groundwater levels above baseflow conditions for 89 days at Lone Dome & 91 days at Big Gypsum.
- The 2011 moderate release (peak release ~1,500 cfs) resulted in groundwater levels above baseflow conditions for 46 Days at Lone Dome & 31 Days at Big Gypsum.

- At the Big Gypsum site, the 2012 baseflow conditions only (no mimic of a snowmelt release) resulted in groundwater levels 4 feet below ground surface for the total duration of the study (117 days), with only the well closest to rivers' edge (Well #1) maintaining any water at all (the other two wells ran dry). The Lone Dome site responded similarly but not as dramatically—no wells ran dry at that site. This noticeable difference in well response to low flows between the two sites is likely a combined result of lower precipitation at Big Gypsum and the increased reliance of groundwater at this site on stream discharge.
- Looking at both sites, years with no peak release resulted in groundwater table depths of approximately 3.8 feet or greater at the Well #2 in the 'young cottonwood zone'.
- High flows and a long-duration release improved water table levels at both sites, with the biggest improvement at Big Gypsum, resulting in groundwater depths of 2 feet or less from the beginning of April through the end of July, providing much needed water for pre-existing adult cottonwoods (Figure 5 below).
- Adult cottonwoods typically need a groundwater depth of less than 1.5m (4.8 ft) to maintain healthy growth (Scott 1999; Shafroth et al. 2000, Rood et al. 2011)
- Both moderate (e.g., 2011) and large (e.g., 2017) releases are valuable for maintaining cottonwood.

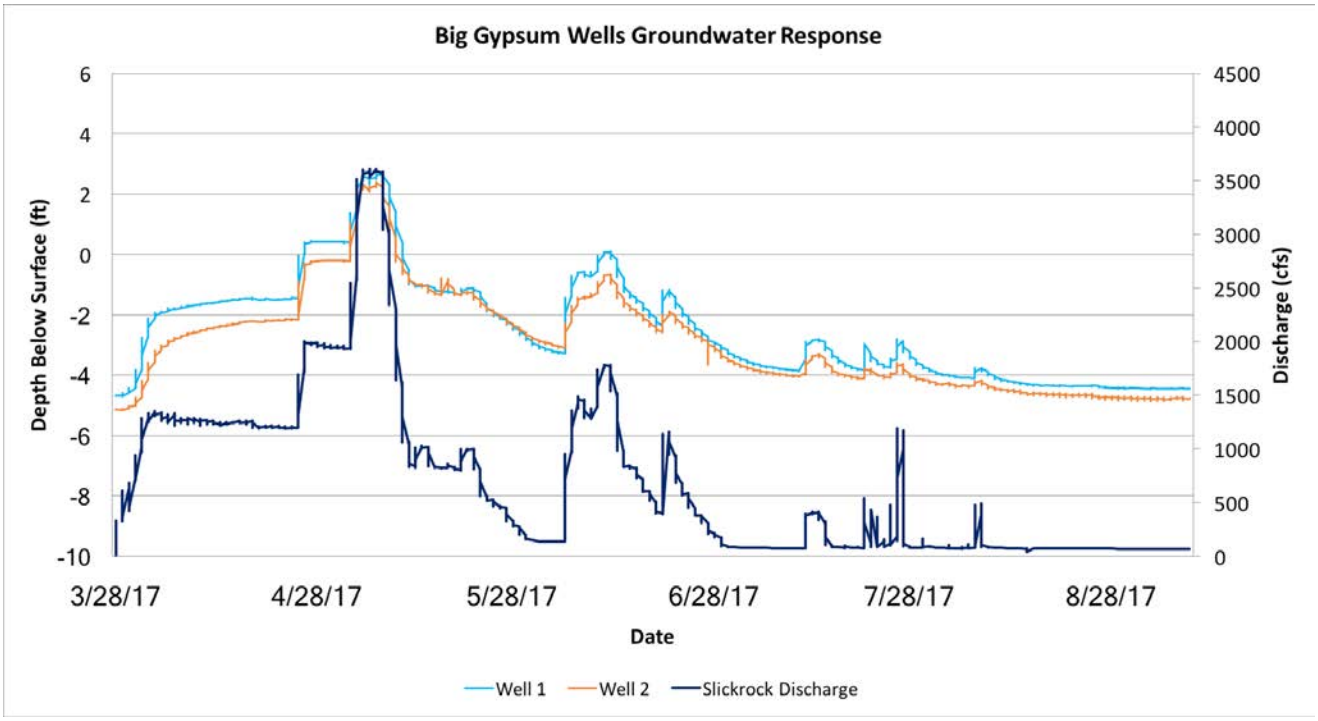


Figure 5. Big Gypsum site in 2017, showing Slickrock Discharge and groundwater well data for a high-flow release. Note that both Well #1 and Well #2 show groundwater depths of 2 feet or less from the beginning of April through the end of July.

Riparian Vegetation Monitoring

Riparian vegetation monitoring in 2017 consisted of: (1) repetition of historic (2003) photo points at select points along the river; (2) establishment and repetition of new photo points at the five new ecological monitoring sites pre-, peak-, and post-release 2017; (3) conducting new cottonwood recruitment surveys post-release on the new ecological monitoring sites; and (4) repetition of historic (2010) vegetation transect monitoring at select points along the river.

Summary of Findings

- Comparison of historic repeat photos confirm noticeable willow encroachment on point bars and river banks from 2003 to 2017, and appear to also have increased in density from 2003 to 2017 along the river bank at the Big Gypsum site (See Figure 6 below).
- However, new ecological monitoring site photo points do show evidence of floodplain scouring and movement of sediment resulting in deposition, creating some new small bare areas.
- The configuration of the channel as seen from above (the planform) was also overall little changed.
- The density of riparian vegetation (mostly willow) and consequent 'armoring' of river banks resulted in very little bank erosion or thinning/removal of riparian vegetation, creating few new bare areas where cottonwood seedlings could establish.
- No new cottonwood seedlings were found on ecological monitoring sites. The most common non-cottonwood seedlings found were willow, occurring at multiple survey areas. Possible reasons for no cottonwood seedlings being found include: (1) cottonwood seed release did not appear to occur until after peak-release; (2) managed release draw down rates appeared to be faster than that that required for successful seedling establishment; and (3) potential high accumulation of salts at some sites.
- Comparison of historic vegetation transects found average willow stem density did not change between 2010 and 2017, indicating the managed release did not reduce willow density. Willows are serving to 'armor' the river banks, resulting in channel narrowing, and represent one of the biggest changes in recent times on the Lower Dolores.
- Percent bare ground was over 40% at the Big Gypsum site, resulting in some seed germination on new seedbeds, but seedlings here were also found to be predominantly willow.

Figure 6 (a-d). Historic Big Gypsum Photo Point #2 (top photos) and Photo Point #6 (bottom photos) taken in 2003 (6/17/03) (photos on left) and 2017 (6/26/17) (photos on right). The photos show how, between these years, riparian vegetation increased in size, cover and density, and bare ground between plants decreased.

Aerial Imagery Monitoring

TNC collected both pre- and post-release drone imagery in 2017 at three of the new ecological monitoring sites (Slickrock Upstream, Slickrock Downstream, and BLM Rec [Big Gypsum]).

Summary of findings

- Pre- versus post-release drone imagery in 2017 revealed virtually no change in river planform (See Figure 7).

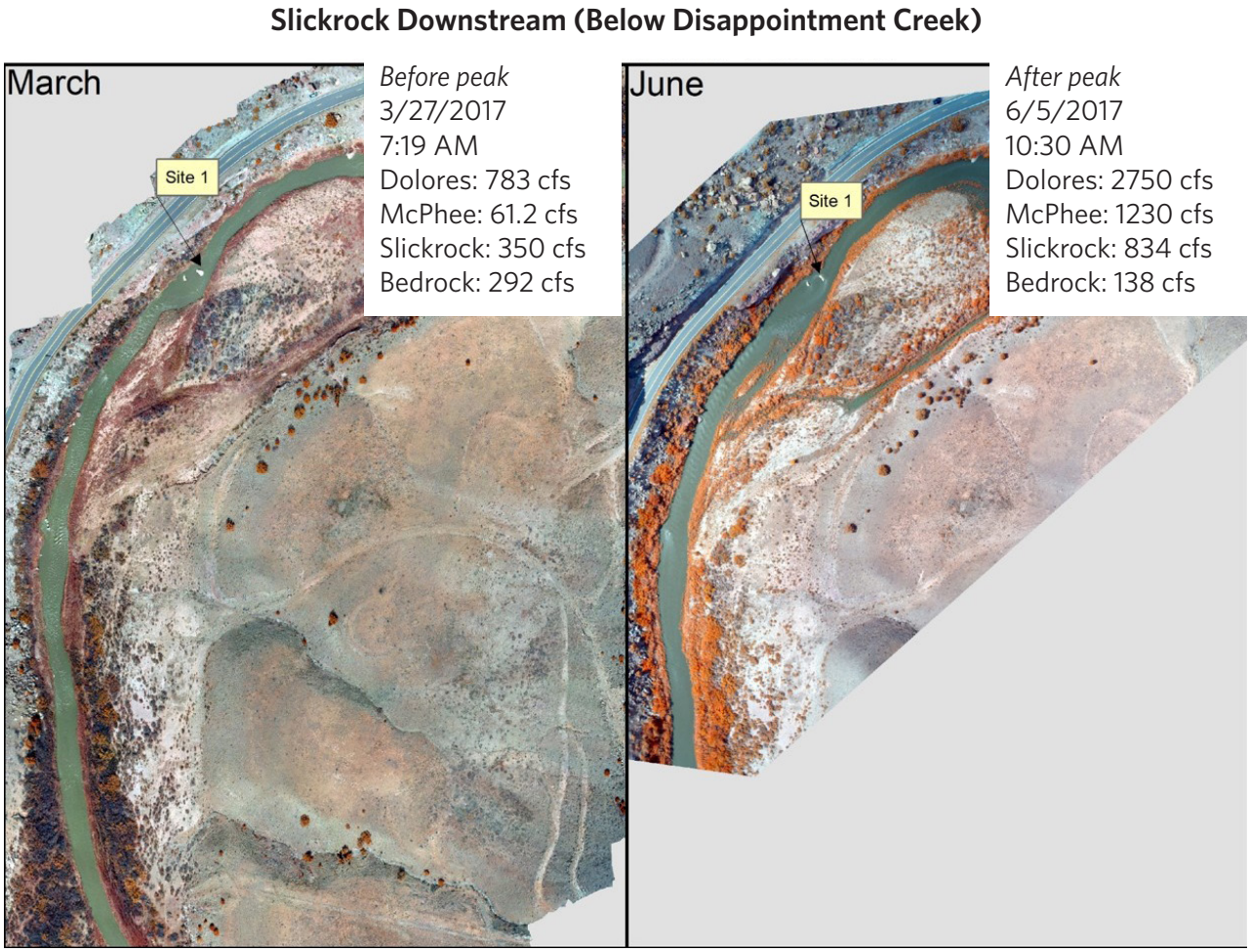
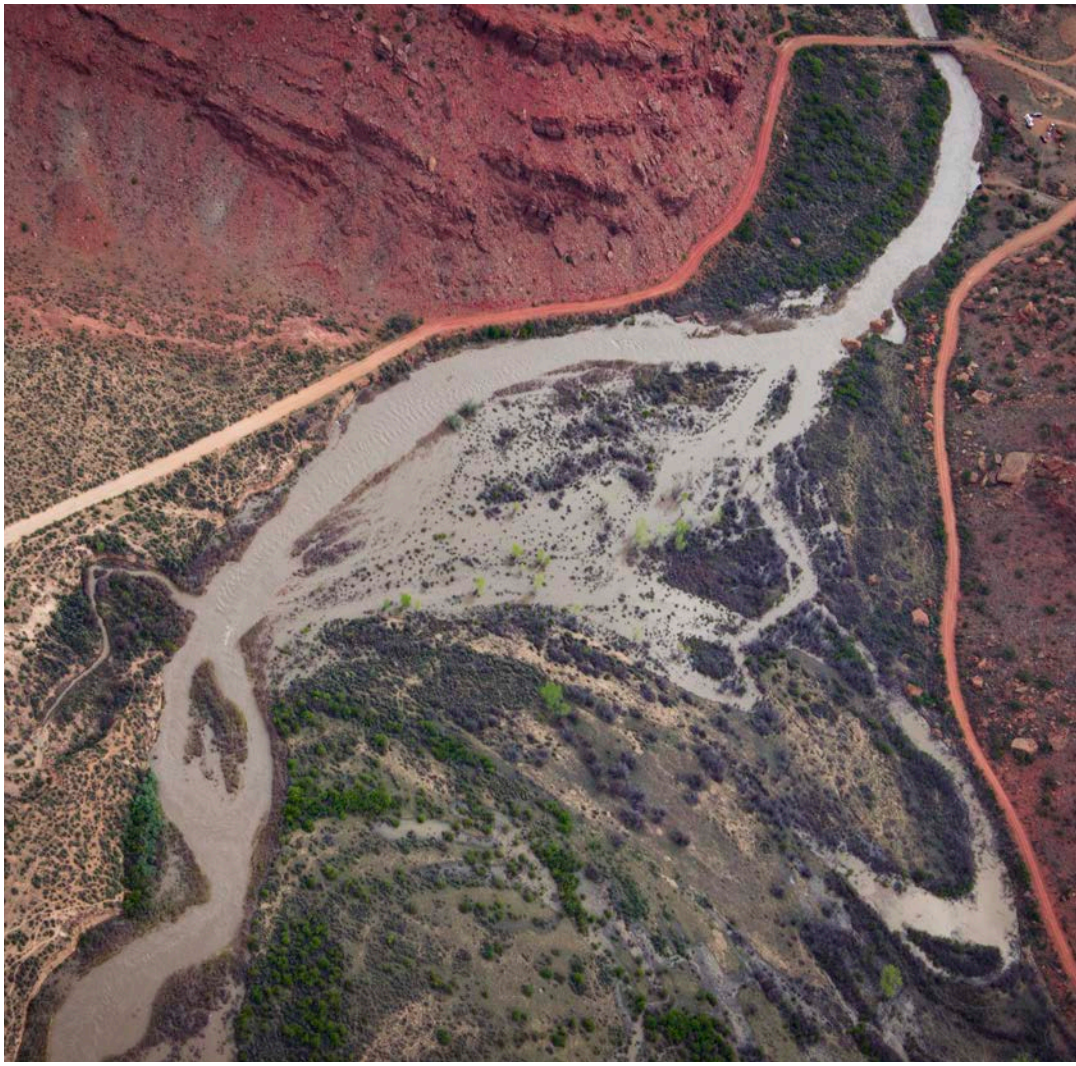


Figure 7. Drone imagery comparison March versus June 2017 at the Slickrock Downstream site. There is very little difference in planform pre- versus post-release. Most of the differences observed is because of higher water levels in June photos. Higher flow caused side-channel flow here, and floodplains stand out as a whiter color because of sand deposits.

TNC is also preparing to conduct analyses comparing 2015 versus 2017 National Agriculture Imagery Program (NAIP) imagery of the Lower Dolores River—specifically comparing change in the channel, vegetated surfaces, and bare ground along the river from McPhee Reservoir to the Colorado/Utah state border.



Clockwise from top left: CPW staff hold a bluehead sucker during a fish survey © *Jim White/CPW*, Dolores River © *John Fielder*, Fish surveying in a tributary © *Celene Hawkins/TNC,* Aerial view of peak release time on the river © *Lauryn Wachs/TNC*, Kayaking on the Dolores © *Lauryn Wachs/TNC*